DEVELOPING RISK MANAGEMENT FRAMEWORK FOR WELLHEAD AND CHRISTMAS TREE EQUIPMENT

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DEDICATION

This thesis is dedicated to my lovely late father Mr. Ramli Taufik bin Tawi Pandito Ibrahim, my lovely mother Mrs. Arlianis, My lovely wife Mrs. Novie Novera, My both daughters Maghfira Izzati and Faiza Dhia Ariqah and my sister Mrs. Nailussaadah, and my brothers Mr Tri Joni Putra, Mr Rahmad Ebtawan, Mr Dedy Fitriawan that has given their love, enthusiasm and really gave me an energy as well as encouragement when I need it.

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ABSTRACT

Poor design may cause product failure, can be affected the manufacturing processes such as delay in delivery time, increased cost, poor quality, lose time, and risk for lost time injury (LTI). To remain competitive in global marketplace the manufacturing wellhead and christmas tree equipment companies need to implement of risk management process, to analysis potential risk and failure. This thesis attempted to investigate an organization's perception of risk management in manufacturing of wellhead and christmas tree equipment and determine the risk management culture that influence the implementation and practices of risk management. The main outcome of this research is to develop comprehensive risk management framework for effective risk management implementation in order to facilitate decision making. This is achieved through detailed review of relevant literatures, standard and survey technique and questionnaires through the research methodology process. The research procedure require collection of data which was obtained from the manufacturing and collection methods involve survey form, meeting with industrial experts and conduct pilot study to enable provision reaching some conclusions. There are 216 respondents from 13 companies in this research who completed and returned the survey form. The results obtained through testing of IBM SPSS statistic version 21 using data collected from industry showed the perception about risk management and implementation of the company in managing risk found that the mean value for the group variable company risk culture and implementation stage is moderate (slight lower 3 from likert scale 1-5) and Pearson correlation is positive and these are 3 factors of competency, motivation, knowledge and risk culture that influence toward implementation risk management successful. In conclusion, the above result satisfy the research aim of facilitating decision making process and the framework and flow diagram proposed in this thesis can be used for a guide to the practitioners and further study.

ABSTRAK

Rekabentuk yang tidak baik boleh menyebabkan kegagalan dalam penghasilan sesuatu produk, menjejaskan proses pembuatan seperti kelewatan masa penghantaran, peningkatan kos, kualiti yang kurang baik dan kehilangan masa yang banyak akibat daripada kecederaan (LTI). Untuk terus berdayasaing di pasaran global, syarikat peralatan "wellhead" dan "chrismast tree" perlu melaksanakan proses pengurusan risiko bagi menilai potensi risiko dan kegagalan. Sehubungan dengan itu, kajian ini adalah untuk mengkaji persepsi organisasi tentang pengurusan risiko dalam pembuatan peralatan "wellhead" dan "chrismast tree" dan juga mengkaji pengurusan budaya berisiko yang mempengaruhi pelaksanaan dan amalan semasa peringkat pembuatan. Hasil utama kajian ini adalah untuk membangunkan rangka kerja pengurusan risiko yang komprehensif bagi pelaksanaan pembuat keputusan dalam pengurusan risiko. Capaian ini diraih melalui kajian terperinci dengan menggunakan kajian literatur, soal - selidik melalui proses kaedah penyelidikan. Prosedur-selidik memerlukan pengumpulan data yang didapat dari syarikat dan kaedah pengumpulan dari borang kajian, temuduga dengan pakar dan kajian awal untuk mendapatkan capaian kajian. Terdapat 216 responden yang melibatkan 13 buah syarikat dalam kajian ini. Data analisis telah dijalankan melalui *IBM SPSS statistic* versi 21 dan nilai purata bagi budaya dan pelaksanaan di dalam sesebuah syarikat didapati berada dalam nilai yang sederhana (kurang 3 daripada skala 1-5) dan korelasi Pearson adalah positif dan menunjukkan bahawa, 3 faktor budaya pengurusan risiko kecekapan, diikuti dengan motivasi, pengetahuan dan budaya berisiko memberi kesan terhadap pelaksanaan pengurusan risiko. Kesimpulannya dari kajian ini adalah rangka kerja pengurusan risiko dan rajah aliran dibangunkan berdasarkan hasil persepsi organisasi dicadangkan dalam tesis ini boleh digunakan untuk kegunaan untuk panduan pakar pengurusan risiko dan kajian seterusnya.

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LIST OF SYMBOLS AND ABBREVIATIONS

α	-	Alpha
ANOVA	-	Analysis Of Varian
API	-	American Petroleum Institute
ARM	-	Active Risk Management
ASME	-	American Society Mechanical Engineer
B	-	Beta value
BOP	-	Blow Out Preventer
BPVC	-	Boiler And Pressure Vessel Code
BSEE	-	Bureau of Safety and Environmental Enforcement
CAD	-	Computer Aided Design
CAE	-	Computer Aided Engineering
CAM	-	Computer Aided Manufacturing
CNC	-	Cumputer Numerical Control
D	-	Detect The Failure Before It Occurs
df	-	Degree of freedom
DOSH	-	Department of Safety And Health
EPC	-	Engineering Procurement Construction
F	-	F value, table and calculation
FEM	-	Finite Element Method
FMEA	-	Failure Mode Effect Analysis
FMECA	-	Failure Mode Effect Critical Analysis
GDPIM	-	Global Development Product Introduction Management
HIRARC		Hazard Identification, Risk Assessment, Risk Control
ISO	-	International Standard of Organization
N	-	Frequency
NIOSH	-	National Institute of Occupational Safety and Health

O	-	Occurrences
φ	-	Phi value
OEM	-	Original Equipment Manufacturer
OFE	-	Oil Field Equipment
OSHA	-	Occupational Safety And Health Act
P value	-	Significant-probability value
PDCA	-	Plan Do Check Action
PDM	-	Product Data Management
PEM	-	Project Execution Module
PFMEA	-	Process Failure Mode Effect Analysis
PM	-	Project Manager
PMBOK	-	Project Management Body Of Knowledge
PMI	-	Project Management Institute
PMO	-	Project Management Office
PR	-	Performance Requirement
PRM		Project Risk Manager
QC	-	Quality Control
QMS	-	Quality Management System
R^2	-	R square, coefficient of determination
RC	-	Risk Culture
RM		Risk Management
RMF	-	Risk Management Framework
RFMEA	-	Risk Failure Mode Effect Analysis
RPC	-	Reinforced Pipe Concrete
RPN	-	Risk Priority Number
S	-	Severity Of The Failure
SCM	-	Supply Chain Management
SHE	-	Safety Health And Environment
SPSS	-	Statistical Product and Service Solutions.
TDM	-	Tailored Design Method
TPMs	-	Technical Performance Measures
UTHM	-	Universiti Tun Hussein Onn Malaysia
UTS	-	Ultimate Tensile Strength

X^2	-	Chi-square value
Xm	-	Motivation
Xc	-	Factor risk culture
Xp	-	Project risk management knowledge
Xcp	-	Competency
Y	-	Predict company risk management implementation stage
YS	-	Yield Strength

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CHAPTER 1

INTRODUCTION

1.1 Research background

Oil exploration and production has played a significant part in the financial success of Asia and the Middle East. In recent years, the demand for oil and gas has increased as well as technological developments. Due to depletion of onshore oil and gas resources, many countries are looking towards marine exploration to fulfil these demands. The main companies supplying wellhead and christmas tree are TechnipFMC Technologies, Aker Solutions Malaysia, KOP Surface product, GE Oil and Gas, with market shares in that order (Hillegeist & Sean, 2013). Oil production companies approach suppliers with an increased focus on risk management and standardized products. The loss of wellhead and christmas tree integrity can result in major accidents and present a severe risk to the environment (Raj, 2013). The oil and gas sector of manufacturer can generate large profits, but has always been characterized by a high degree of risk. Companies are faced by a number of risks not only related to finding oil or gas under the ground with competiveness of equipment technology, but also financial, political, and manufacturing risks (Svoda & Yue, 2016). Manufacturing risk is therefore important and must be handle at base during the design and manufacturing stage.

One example of a wrongly manufactured wellhead and christmas tree equipment referred to Bureau of Safety and Environmental Enforcement (BSEE, 2017). The report made regarding wing valve failure in christmas tree equipment (BSEE, 2017). The executive summary of the report found that the flange bonnet wing valve failed at an Original Equipment Manufacturers (OEM) test facility. The wing valve was exposed to pressure loading tests at three different sites during manufacture and qualification testing. The investigation indicated that overpressure occurred during testing at one of the facilities, leading to the failure of the wing valve. The overpressure was attributed to the lack of test fixtures for overpressure protection, and the lack of automated pressure control. Additional information obtained by the BSEE indicated that there was also the possibility of design deficiencies in the wing valve, including lower yield strength (YS), ultimate tensile strength (UTS) retainer ring material properties, and insufficient thread engagement for its intended purpose. A third party provided additional data to the BSEE, indicated that lower safety factors than those calculated by the OEM were used during qualification testing. In this case, the safety factors were calculated with the material yield shear strength rather than with the material ultimate shear strength. If safety factors with respect to yield shear strength were less than 1.0, then the threads would yield but not necessarily fail. Conversely, if the safety factors with respect to ultimate shear strength were less than 1.0, the threads would fail. The failed fasteners can be seen in Figure 1.1. In both cases, the safety factors should be greater than 1.0, as an appropriate engineering measure of safety, to ensure that the equipment can withstand the required pressure. Therefore base on this case risk can be reduced by reducing the potential failure of equipment at the manufacturing stage.

Recommendation from the Root Cause Analysis (RCA) report by OEM industry is to make design changes to the OEM retainer ring's material properties to reduce the risk of failure in the future. However, the OEM may need to consider additional evaluation of the wing valve design to ensure adequate thread engagement with the retainer ring in order to further reduce potential failures and risk. Retainer ring material properties should be compared to fastener material properties to ensure consistent load paths, adequate closure bolting, and to verify that the valve is fit for service. Wing valve designs should provide adequate allowance for thread engagement, while its manufacturing procedures should be evaluated to verify proper thread engagement prior to qualification testing. The BSEE should require operators to provide supporting documentation detailing why a wing valve is not required to meet American Petroleum Institute code 6A (API 6A).

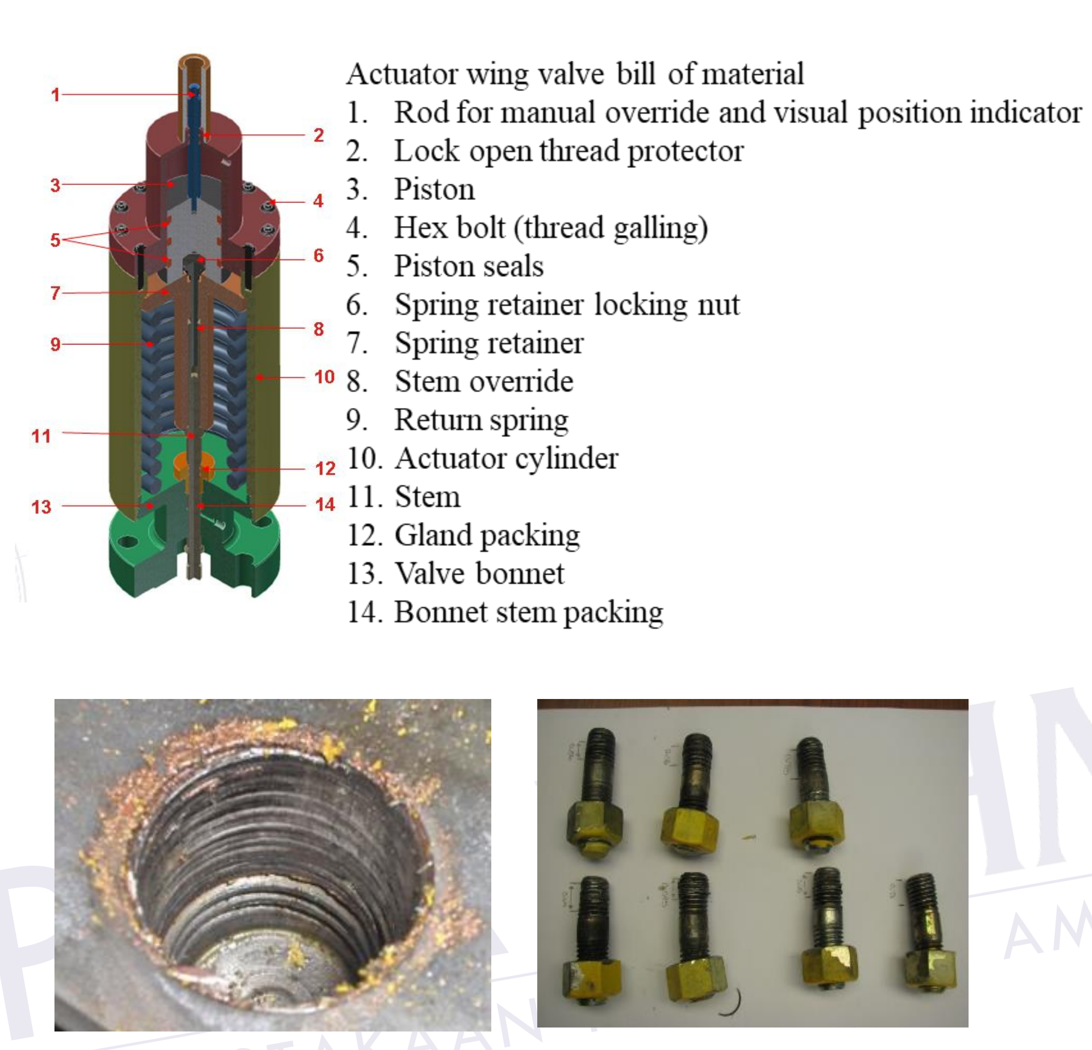

Figure 1.1: OEM failure analysis in manufacturing facility test of christmas tree wing valve failure (BSSE report, 2017)

Companies are required to ensure the required wellhead and christmas tree is properly maintained. They should select competent people who are well versed with well operations and up to date with the latest well status. Good communication between all parties involved is required so that correct information is circulated between customer sales representatives, the project team and the manufacturing team (Hamid, Baba & Sani, 2017b). Since there have been problems and accidents caused by poor handover documentation and communication, all relevant information with regards to barriers, operational limits, valve status, the well design, and other critical information have to be compiled as part of a handover package. Good routines and organizational solutions should be implemented to maintain the required safety levels in offshore operations to reflect products made during the manufacturing processes (Bigliani, 2013).

All wellhead and christmas tree equipment produced by the manufacturer must comply with the requirements of relevant standards in the petroleum and gas (production and safety) Regulation 2004 (e.g. ISO 10423 based on API 6A specification). Any wellhead or petroleum equipment that do not comply with the relevant standards should be identified to the inspectorate and actions should be taken to comply with the regulation (Matheson, 2011).

Existing management products in oil and gas companies have many advantages such as shorter production flow and lower production cost. However, they have some weaknesses when it comes to applications after manufacturing. Case studies show that some companies lack focus on new product development/design. One report stated that delivered equipment could not be installed because the interfacing design failed to provide a proper connection, thus causing the project to fail. Other cases involved the high percentage or numbers of engineering changes, nonconformance during the process, or manufacturing issues (API 6A, 2011).

Managers have to take into account the interface design according to the client's product specifications, and feasibility in the field. All of these pose risks that should be predicted and tackled systematically as soon as possible in order to reduce the difficulty of risk mitigation. The lack of initiative in risk identification during the initial manufacturing process affects manufacturing objectives. Some barriers and process constraints become risks because of the lack of systematic risk identification during the manufacturing process. New products in particular, require strict monitoring during the engineering stage so that they comply with customer specifications, needs, requirements, and industry standards. Risk should be evaluated right from the beginning stage.

1.2 The importance of risk management

In oil and gas industries especially those related to production, innovation and efficient equipment is crucial in retaining a competitive edge in the market. In order to ensure the success of a product, proper risk management (RM) is implemented in order to manage and eliminate the risks that could lead to the failure of a project (Rogers & Ethridge, 2013). However, organizations cannot engage in RM without developing inhouse knowledge. Identification and response to risk factors in each organization depends on its intellectual capital. the knowledge and judgment of its personnel. Therefore, the main decision makers of an organization (in an organization level) should collect and manage the collective knowledge, culture, and systems of their teams and employees in order to recognize and mitigate risk factors in an efficient manner (Jafari *et al.*, 2011).

Risk management has become an important part of manufacturing. The oil and gas industry has attracted the attention of researchers due to the various problems and issues faced during the equipment manufacturing. Hillegeist & Sean (2013) demonstrated one such event, where failure happened during application after manufacturing (on site). In 2010, the loss of well integrity during oil drilling by BP's Monaco resulted in a blowout in the Gulf of Mexico. This serves as a reminder of the potential dangers of the oil and gas industry. Studies have found that the loss of well integrity increases the chances of failure. The general consensus is that organizations should implement risk management at every stage of the manufacturing process (Torbergsen *et al.*, 2012).

RM should be undertaken by the engineering side because they not only perform design calculations and analyses, but are also involved in approving and performed overall in manufacturing process. Engineers should follow the industry standards such as American Standard Petroleum (API 6A) for design guideline and American Society of Mechanical Engineer (ASME). API 6A is a set of guidelines for manufacturing wellhead and christmas tree, as well as other equipment. The guidelines have to be followed strictly, with only small deviations allowed to account for the manufacturing of improved and innovative designs. However, these deviations have to be evaluated, monitored, and managed properly in order to mitigate the risks involved. A critical part of risk management and mitigation is the usage of proper design that take into account well-field conditions, various environments, climate, procurement, manufacturing, and the logistics of equipment delivery for the drilling process by the end user (API 6A, 2011).

To achieve the manufacturing project objectives and meet deliverables, a good planning and risk management model should be implemented before commencing with the manufacturing process (Whitman, 2012). The risk management model or framework should include all work tasks, engineering design tasks, estimate and cost control sheets, project scheduling and time sheets, the

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